Lab 2: Report

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- **Microbenchmark Justification:**

The microbenchmark is made of a for loop and a conditional statement. Both of these statements are translated into a branch instruction. Since the 2 level predictor has a history of 6 bits, we created a condition such that the if statement is only taken on multiples of 6. The history for that branch is NNNNNT and this can be fully captured by the 6 history bits. We ran this loop 1000000 times to avoid any overhead, and allowed enough learning time for the predictors. We got the following results:

NUM_INSTRUCTIONS : 19251617
NUM_CONDITIONAL_BR : 2013699 (This is as expected because there are 2 million branches: 1 million from the for loop and 1 million from the if statements)

2bitsat: NUM_MISPREDICTIONS : 168184
2bitsat: MISPRED_PER_1K_INST : 8.736
2level: NUM_MISPREDICTIONS : 1324
2level: MISPRED_PER_1K_INST : 0.069

From these results, we can see that the 2 level predictor performs much better than the 2bit predictor. This is expected because each branch has a private history and a history of 6 bits is used as an index to get a prediction specific to that history pattern (capturing the repetition in the pattern).

- **MPKI for All Three Predictors:**

	Bimodal	**2 Level**	**Open End**
astar	24.639	11.903	5.868
bwaves	7.876	7.146	5.665
bzip2	8.167	8.651	8.335
gcc	21.143	14.824	5.578
gromacs	9.007	7.484	5.517
hmmer	13.567	14.872	11.957
mcf	32.981	13.494	10.442
soplex	8.220	6.819	5.542
Average	**15.7**	**10.649125**	**7.363**

- **Open Ended Branch Predictor Implementation Description**

  For the open ended branch predictor, we implemented a predictor similar to the TAGE predictor (without the tags and usability bits). We created 4 levels for this predictor. The first level is the normal Bimodal predictor with 4096 entries. In addition, we have three other tables with increasing history bit

length which is compared to a 32-bit global history register. The following is a description of the three tables:

1. Table 1: It is indexed with (4 least significant bits of PC XOR 4 least significant bits of global history register). Each entry uses a two bit counter.
2. Table 2: It is indexed with (8 least significant bits of PC XOR 8 least significant bits of global history register). Each entry uses a two bit counter.
3. Table 3: It is indexed with (15 least significant bits of PC XOR 15 least significant bits of global history register). Each entry uses a three bit counter.

Results are obtained from all these tables. If there is a match in the tables (value returned is not -1), priority is given in the following order from highest to lowest: Table 3, Table 2, Table 1, Bimodal.

This predictor had an average MPKI of 7.363.

- **Area, Access Latency and Leakage Power**

	Two Level Predictor	**Open-Ended Predictor-1 (Bimodal)**	**Open-Ended Predictor-2 (Table 2)**	**Open-Ended Predictor-3 (Table 3)**
Configurations	Cache size : 1024 Block size : 1 Associativity : 1	Cache size : 4096 Block size : 1 Associativity : 1	Cache size : 256 Block size : 1 Associativity : 1	Cache size : 32768 Block size : 1 Associativity : 1
Area	0.0730062 x 0.0265122 = 0.00193556 mm^2	0.136392 x 0.0498334 = 0.006797mm^2	0.0420814 x 0.0142597 = 0.0006001 mm^2	0.259793 x 0.180395 = 0.0468654 mm^2
Access Latency	0.164342 ns (Access Time)	0.21062 ns (Access Time)	0.147232 ns (Access Time)	0.343503 ns (Access Time)
Leakage Power	0.366395 mW	1.52325 mW	0.0993983 mW	10.3838 mW

Note: CACTI does not allow us to model cache sizes smaller than 64B. As Table 1 is only 16 bytes, we did not model it.

- **Work Division Statement**

  For this lab, we used the pair programming method and did the entire lab together. We both working on each component of the lab together.